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**NETWORK FOR IMPLEMENTING LOCALIZED ROAMING OF MOBILE  
SUBSCRIBERS AND METHOD FOR IMPLEMENTING LOCALIZED ROAMING**

**Field of the Invention**

5       The present invention relates to a mobile communication network as well as a method for implementing roaming of mobile subscribers.

**Background of the Invention**

10       In the traditional mobile phone roaming procedure, communication links have to be established between the mobile networks both in the home region and in the roaming region to support calls of mobile subscribers in roaming state and to enable mobile subscribers in roaming state to use diverse telecom  
15       services, such as initiating calls or answering calls. etc. However, since communication route is long and more network resources are consumed in roaming state, the service cost in roaming state is higher than that in normal state. Especially, in international roaming state, any call to the subscriber is  
20       international long-distance call, i.e., the call has to be accomplished through the communication links between the mobile network in the home country and that in the roaming country; therefore, the roaming subscriber has to pay the international long-distance cost from the home country to the roaming country;  
25       even though the caller is within a stone's throw to the roaming subscriber (e.g., when two members in a tourist party are calling in a roam region), both parties have to pay the toll for international call. As a result, the communication demand of roaming subscribers is suppressed by the expensive cost.  
30       Therefore, people are eager to implement localized roaming of

mobile phones to decrease expensive roaming call cost.

However, the traditional mobile networks can't meet such a demand. The structure of a typical traditional mobile network is shown in Fig.1. As shown in the network in home country in Fig.1, the network entities related to mobile phone roaming processing in an traditional network include Base Transceiver Station BTS, Base Station Controller BSC, Mobile Switching Center MSC, Visiting Location Register VLR and Home Location Register HLR. For example, when the subscriber's mobile phone is roaming in different countries, the mobile phone has to use its number N in the home country wherever it is because the number of the mobile phone N is stored in the HLR of the subscriber's home network. A call to the roaming subscriber has to be switched to the home country of the subscriber, so that the MSC in the subscriber's home country can inquire HLR in the home country for the route and establish the voice path to the roaming country. However, in many cases, this is unnecessary; for example, when the caller is in the roaming country where the called subscriber is or a call is initiated from the third country except for the home country or the roaming country where the called subscriber is. Even though it is unnecessary, the roaming subscriber has to bear the charge for international long distance call from the home country to the roaming country.

## **Summary of the Invention**

To solve above problem, the present invention provides a network for implementing localized roaming of mobile subscribers and a method for implementing localized roaming network, localized roaming of mobile subscribers can be implemented at lower cost and with lower network resource

occupation through the network and method provided by the present invention.

To implement localized roaming service, the network for implementing localized roaming of mobile phones comprises Base  
5 Transceiver Station BTS, Base Station Controller BSC, Mobile  
Switching Center MSC, Visiting Location Register VLR and Home  
Location Register HLR and further comprises at least one Roaming  
Number Manager RNM;

Said Roaming Number Manager, connected with the HLR, is used  
10 to manage mobile phone numbers in the home region and the  
contracted roaming regions; said RNM takes the collection of  
obtained mobile phone numbers in the contracted roaming region  
as a resource pool, and allocates the mobile phone numbers in  
the contracted roaming region to roaming subscribers  
15 dynamically.

Said Roaming Number Manager (RNM) may also be embedded in  
said HLR.

The method for implementing localized roaming of mobile  
subscribers based on said network comprises:

20 a. configuring the RNM with a number in a contracted roaming  
region/network, an independent PSTN/ISDN (Public Switched  
Telephone Network/Integrated Service Digital Network) number  
and a signaling point code;

b. configuring data in the entities of the contracted roaming  
25 region/network and that of the home network, so that the  
subscriber location inquiry message taking the local number in  
the subscriber's roaming region/network as the destination  
address will direct to RNM in the subscriber's home network;

c. establishing interfaces between the RNM and entities of  
30 the contracted roaming region/network as well as between the

RNM and entities of the home network;

d. the subscriber utilizing the configuration in respective entities of the contracted roaming region/network and the home network to develop communication services in the roaming region/network, implementing localized roaming of the subscriber.

Said step c comprises:

c1. establishing an interface between RNM and MSC;

c2. establishing an interface between RNM and HLR.

Said step d comprises a subscriber location update process:

d1. the Visiting Location Register VLR at which the subscriber is registered currently sends a location update request to the HLR in the subscriber's home region;

d2. according to the location update request received from the VLR and the current location of the subscriber, the HLR in the subscriber's home region addressing the RNM corresponding to the current subscriber location through the RNM's PSTN/ISDN number and informing RNM of the subscriber location update;

d3. the RNM allocating a mobile phone number, i.e., a number in the roaming region/network, to the subscriber, and returning said number in the roaming region/network to HLR in the home region;

d4. the HLR in the subscriber's home region inserting said number in the roaming region/network in the VLR at which the subscriber is registered currently, and returning an acknowledgement message of obtaining said number in the roaming region/network to RNM.

In step d3, before allocating a mobile phone number to the subscriber, the RNM determines whether the roaming region where the subscriber's mobile phone is roaming is a contracted roaming

region; if so, RNM allocates one from the available numbers in the contracted roaming region and feeds it back to HLR in the home region; otherwise RNM feeds the subscriber's number in the original home region to HLR in the home region.

5        Said method also comprises: when the subscriber's mobile phone receives an incoming call or initiates an outgoing call, it processes the call utilizing the number fed back from RNM in the subscriber's home region.

         In detail, the call processing is: when serving as the caller,  
10    the subscriber's mobile phone uses the number fed back from the RNM in the subscriber's home region to initiate a call; when the subscriber's mobile phone serves as the called, the Mobile Switching Center (MSC) in the subscriber's roaming region or the MSC in the subscriber's home region inquires for the call  
15    route in Home Location Register (HLR) in the subscriber's home region; the Home Location Register (HLR) in the subscriber's home region inquires for the subscriber corresponding to the called number in the Roaming Number Manager (RNM) in the subscriber's home region, to find corresponding subscriber  
20    record, and to obtain the address of Visiting Location Register (VLR) corresponding to the subscriber's roaming, and then accesses said VLR to obtain routing information to instruct the Mobile Switching Center (MSC) in the subscriber's roaming region to establish the call.

25        Said method also comprises: when the subscriber's mobile phone leaves the contracted roaming region, the Home Location Register (HLR) in the subscriber's home region informs the Roaming Number Manager (RNM) in the subscriber's home region of the subscriber location update, the RNM in the subscriber's  
30    home region releases the mobile phone number, occupied by the

subscriber, in the old roaming region, and breaks the mapping between the number and the subscriber.

It is according to the subscriber's IMSI (International Mobile Subscriber identifier) that said VLR in step d1 addresses  
5 the HLR in the subscriber's home region.

The information carried in the location update request sent from VLR to HLR in step d1 and the parameters carried in the location update informed from HLR to RNM in step d2 comprise:  
the subscriber's IMSI and/or the mobile phone number in the home  
10 region, the subscriber's current location information and the subscriber's old location.

Since a RNM is configured in the network provided by the present invention, a local mobile phone number in the roaming region can be allocated to the subscriber through the RNM  
15 according to the mobile subscriber's roaming region, and said number is released when the subscriber leaves the roaming region; therefore the subscriber can use the number in its roaming region during roaming to initiate calls or answer calls and thus enjoy localized roaming service, for example, the subscriber needn't  
20 to pay the charge for international long distance call when he/she answers the call; such a network can reduce network resource occupation when mobile subscribers communicate in roaming state, and reduces greatly subscribers' communication cost in roaming state; for operators, the network according to  
25 the present invention can provide a new localized roaming service and can extend services to other regions or countries to exploit new markets, attract subscribers, improve subscriber's loyalty, and encourage subscribers to use mobile phones in roaming state; in addition, the present invention requires little modification  
30 to traditional mobile networks, low cost and convenient

implementation.

In the method according to the present invention, since reasonable addressing for RNM as well as respective communication processing, the HLR can obtain services from different RNMs according to the subscriber's roaming region, and a single RNM can provide services for a plurality of HLRs; thereby the flexibility of network structure is enhanced, and utilization rate of numbers in the roaming region is improved; the interfacing between mobile communication network devices is simplified; the impact of implementation of localized roaming to traditional devices in mobile communication networks is reduced, i.e., RNMs should be introduced into traditional mobile networks to implement localized roaming with minimum impact.

#### **Brief Description of the Drawings**

Fig. 1 is the structural diagram of an traditional cellular mobile communication network;

Fig. 2 is the structural diagram of the cellular mobile phone network according to the first embodiment of the network of the present invention;

Fig. 3 is the structural diagram of the cellular mobile phone network according to the second embodiment of the network of the present invention;

Fig. 4 is an organizational chart of the data structure employed in the network of the embodiment of Fig.3;

Fig. 5 is the structural diagram of the cellular mobile phone network according to the third embodiment of the network of the present invention;

Fig. 6 is the structural diagram of a cellular mobile phone network implemented with the method according to the present

invention;

Fig. 7 is the flow diagram of the first embodiment implemented with the method according to the present invention;

Fig. 8 is the roaming subscriber location update signaling flow used in the present invention;

Fig. 9 is a signaling flow used in the present invention, through which the roaming subscriber is called by means of a number in the roaming region;

Fig. 10 is a signaling flow used in the present invention, through which a short message is sent to the subscriber by means of a number in the roaming region;

Fig. 11 is a signaling flow used in the present invention, through which the roaming subscriber is called by means of a mobile phone number in the home region;

Fig. 12 is the flow diagram of the second embodiment of the method of the present invention.

#### **Detailed Description of the Embodiments**

The localized roaming described in the present invention refers to that the subscriber's mobile phone in roaming state obtains a local number in the roaming region and initiates calls or answer calls with the number, so that the subscriber can utilize network resource in the roaming region and enjoy localized services, similar to a local subscriber in the roaming region, and thus avoiding unnecessary voice path detour and reducing communication cost in roaming state.

In the implementation of localized roaming of mobile phones according to the network provided by the present invention, the home network where the subscriber's mobile phone is allocated a local mobile phone number in the roaming region to the mobile



phone subscriber automatically according to the roaming region where the subscriber's mobile phone is roaming and if the roaming region is a contracted roaming region, and inform the subscriber of the number. When the subscriber leaves the contracted roaming region, the home network releases the temporary number used by the subscriber. In a contracted roaming region, the subscriber uses the local number to initiate calls or answer calls and enjoy localized roaming service. For example, when the subscriber is roaming in a roaming country, the subscriber needn't to pay the charge for international long distance calls when he/she answers calls; thus the communication cost in roaming state is reduced greatly.

The present invention will be described in further detail taking the roaming across countries as an example, with reference to the attached drawings.

Fig. 2 is the structural diagram of the cellular mobile phone networks according to embodiment 1 of the present invention. As shown in Fig.2, there are 3 networks. The network entities according to the present invention refer to the home network, which comprises: Base Transceiver Station BTS1, Base Station Controller BSC2, Mobile Switching Center MSC3, Visiting Location Register VLR4 and Home Location Register HLR5, and Roaming Number Manager RNM6 connected with HLR5;

Said RNM6 is a network entity, which is used to manage mobile phone numbers in the home country and contracted roaming country; said RNM takes the collection of obtained mobile phone numbers in the contracted roaming country as a resource pool, and allocates the mobile phone numbers in the contracted roaming country to roaming subscribers dynamically; furthermore, RNM is also used to:

(1) Store mobile phone numbers in the home country and the contracted roaming country as well as the mapping between said numbers and subscribers;

(2) determine the current default phone number of the subscriber. When the subscriber roams to the contracted roaming country, the RNM allocates a mobile phone number from the available numbers in the contracted roaming country to the subscriber as the current default phone number of the subscriber in the roaming country, and stores the mapping between the subscriber and the number; otherwise RNM designates the subscriber's mobile phone number in the home country as the current default phone number of the subscriber in the roaming country;

(3) release the local phone number in the contracted roaming country which is allocated to the subscriber. When the mobile phone subscriber leaves the contracted roaming country and registers his/her location in another country, the HLR in the home country inform the RNM in the home country of the subscriber's location update to indicate that the subscriber has moved out of the country; in this case, RNM releases the local mobile phone number occupied by the subscriber and break the mapping between the number and the subscriber. The time span from allocation of the number to releasing is called the life time of the number;

(4) take an appropriate policy to reuse the released local number in the contracted roaming country. To avoid any possible subscriber number conflict in the dynamic allocation process, RNM reuses released numbers with certain anti-conflict policies or combinations of policies. A simple but practicable policy is: the released number is locked temporarily within a certain

time period, which is proportional to the life time of the number; after the time period, the number may be reallocated to a roaming subscriber. RNM stores and exercises above policies.

(5) bind a number in the contracted roaming country to the subscriber. According to the demand of mobile phone subscriber, a number in the contracted roaming country is bound to the subscriber for a long term, and said number can't be allocated to any other roaming subscriber. Even if the subscriber is not in the roaming country, the mapping between the number and the subscriber is still maintained. Above operation is called number binding, and the binding relation is stored in the RNM in the home country.

If the network shown in Fig.2 is used, the operator delivering localized roaming service requires obtaining mobile phone numbers in some roaming countries for the roaming service; those countries are called contracted roaming countries, and the amount of the required phone numbers in a contracted roaming country relates to the number of subscribers roaming in that country. The more the roaming subscribers are, the more the required phone numbers are, and thus the more the required RNMs are. Therefore, the number of RNMs required in the network according to the present invention should be configured as required, such as 2, 3, etc. To facilitate describing the network according to the present invention, hereunder the present invention is described with a network that has only one RNM as an example. As shown in Fig.2, in the home country, the subscriber uses number N; in the contracted roaming country A, he/she uses a local mobile phone number N1; in the non-contracted roaming country B, he/she still use the mobile phone number N in the home country.

In the cellular mobile communication network in the embodiment shown in Fig.2, Base Transceiver Station BTS 1 is a device that transmits or receives radio signals and serves a certain area and establishes radio connections with mobile phone in the area; BTS1 is connected to Base Station Controller BSC2, which manages radio resource and controls the operation of BTS1; Mobile Switching Center MSC3 is mainly designed to control mobile call process; Visiting Location Register VLR4 is designed to store the data of mobile phone subscribers that are roaming in the region dominated by it. All of above devices are standard ones in a mobile communication network. Roaming Number Manager RNM6 is only visible to Home Location Register HLR5 but invisible to other network entities. HLR, VLR, MSC, and RNM cooperate with each other to manage mobile subscribers.

Hereunder the network provided by the present invention and RNM are further described with the interaction between RNM and HLR in the mobile phone location update and route inquiry process:

In the network shown in Fig.2, first, the home country where the mobile phone obtains some mobile phone numbers in the contracted roaming country; when a mobile phone is roaming into the contracted roaming country, it registers its location at the local VLR through BTS, BSC and MSC; VLR initiates a location update request to the subscriber's HLR. HLR determines the location change of the subscriber's mobile phone, i.e., HLR determines whether the country where the subscriber's mobile phone is after the location change changed; HLR informs RNM that the subscriber's location has changed and requests to allocate a mobile phone number in the roaming country to the subscriber's mobile phone. The RNM in the home country determines if the

subscriber is in a contracted roaming country; if the subscriber is in a contracted roaming country, RNM allocates a number from the available mobile phone numbers in the contracted roaming country and feeds the number back to HLR, and stores the mapping  
5 between the number and the subscriber (the mapping may involve multiple numbers, such as the number in the home country, the temporary local number in the roaming region, and bound numbers); if not, RNM feeds the number in the subscriber's home country back to HLR. The above number fed back by RNM to HLR is called  
10 the current default number of the subscriber. HLR inserts the current default number of the subscriber fed back by the RNM in the home country and other data in the VLR of the current region where the subscriber is, deletes the subscriber record in the original VLR, updates the mobile phone location  
15 information in the subscriber record, and informs the subscriber of the current default phone number; if the current default phone number doesn't change, the notification procedure may be omitted. In Fig.2, when the subscriber roams from the home country into the contracted roaming country A, the HLR in the home country  
20 allocates a local mobile phone number N1 in the roaming country to the subscriber, and inserts number N1 and other data of the subscriber in the VLR in country A where the subscriber is currently, deletes the subscriber record in the VLR in home country, and informs the subscriber of the current default phone  
25 number N1; if the subscriber roams into the non-contracted roaming country B, RNM instructs to use the mobile phone number N1 in the home country; the HLR in the home country inserts number N and other data of the subscriber (e.g., contract data) in the VLR in country B the subscriber is.

30 When the subscriber answers an incoming call or initiates

an outgoing call in the contracted roaming country, the subscriber's mobile phone uses the mobile phone number in the current roaming country to process the call. That is to say, when the mobile phone of the roaming subscriber serves as a caller, it uses the temporary roaming number allocated by RNM (i.e., the current default mobile phone number of the subscriber) to initiate the call; when it is a called, the caller may dial the local mobile phone number in the roaming country or the mobile phone number in the home country, and the MSC in the roaming country (if the caller dials the number in the roaming country) or the MSC in the home country (if the caller dials the number in the home country) inquires the HLR in the home country where the called subscriber is for the calling route; The HLR in the home country inquires for the subscriber corresponding to the called number in the RNM in the home country (here the called number is a complete phone number comprising country code and local phone number) to find the corresponding subscriber record and obtain subscriber location information (i.e., the address of the VLR in the current roaming country), and thus obtains the routing information through accessing the VLR in the roaming country, and then instructs the MSC in the roaming country to establish the call. In the RNM in the home country, if any number maps to a subscriber, the mapping is unique; however, a subscriber may correspond to numbers in different countries; no matter which number is dialed by the caller, HLR can find the unique subscriber record and thus obtain the routing information. In Fig.2, when the subscriber roams into country A, the calling subscriber who calls the roaming subscriber may dial either number N or N1.

Only when the country after subscriber location update varies,

the action of allocating a mobile phone number in the roaming country will be triggered. As long as the subscriber stays in the country, above number will be used, until the subscriber's mobile phone registers its location in another network. After  
5 above phone number allocation process is finished, the network will inform the roaming subscriber of the temporary number in the local roaming country in some ways: short message, voice or Unstructured Supplementary Service Data (USSD) are possible ways to be used , depending on the capability of the network  
10 and the operator's choice.

When the mobile phone subscriber leaves the contracted roaming country and enters into another country, the HLR in the home country will inform the RNM of the subscriber location update (i.e., the subscriber leaves the country), RNM will  
15 release the local mobile phone number occupied by the subscriber and break the mapping between the number and the subscriber. The time span from allocation to releasing is called the life time of the number. For example, as shown in Fig.2, when the roaming subscriber leaves country A, RNM will releases number  
20 N1.

In addition, to avoid any possible conflict between subscriber numbers during dynamic allocation, certain anti-conflict policies may be used to reuse the released numbers. In this embodiment, the policy is: the released number is locked  
25 (unavailable) temporarily within a certain time period, which is proportional to the life time of the number; after that time period, the number may be reallocated to another roaming subscriber.

If a mobile phone subscriber frequently travels between the  
30 home country and a contracted roaming country and requires to

possess a number in the contracted roaming country for a long term, a number may be allocated to the subscriber from the available numbers in the contracted roaming country as a fixed number, which will not be allocated to any other roaming subscriber; even though the subscriber leaves the contracted roaming country, the mapping between the number and the subscriber is still maintained. Above operation is called number binding. When the subscriber roams into above contracted roaming country, the HLR in the home country is triggered by a location update request to request the RNM to allocate a local mobile phone number to the subscriber, RNM will return the bound number to HLR, so that the subscriber is enabled to use the bound number to process calls. When the subscriber doesn't need the bound number any more, the binding may be broken, and the number will be released and reused. Certainly, numbers in multiple contracted roaming countries may be bound to a subscriber.

When the caller dials a bound number of the called subscriber, the HLR in the home country of the called subscriber will ascertain the subscriber corresponding to the number, find the subscribers record, and obtain the subscriber's location information (address of VLR), to accomplish route inquiry. Therefore, if the called subscriber has a bound number, the caller will have more choices: the called subscriber's number in the home country, the bound numbers, or the number in the current contracted roaming country.

Fig.3 shows a preferred embodiment 2 according to the present invention, wherein RNM is integrated into HLR as a module. In the embodiment 2, HLR is enhanced in functionality: it not only stores subscriber data (including subscriber identification number, current default mobile phone number, type of contracted



service, current location (address of VLR), etc.) but also delivers the following functions: managing mobile phone numbers in the home country and the obtained from the contracted roaming countries, allocating temporary mobile phone numbers in the roaming countries to roaming subscribers, and storing mapping  
5 between subscribers and numbers, and release the temporary numbers used by the subscribers when subscribers leave contracted roaming countries.

Fig. 4 is a organizational chart of the data structure  
10 employed in the network in the embodiment described in Fig.3. The organizational structure of HLR comprises 3 types of tables: index table of countries, table of local mobile phone numbers, and table of subscriber records. The index table of countries lists home country, contracted roaming countries, and address  
15 of table of local mobile phones corresponding to these countries; it can be used to locate the tables of local mobile phone numbers in the home country or the contracted roaming countries. Countries not included in it are non-contracted roaming countries; the table of local mobile phone numbers can be used  
20 to inquire for the subscriber corresponding to a called number and then inquire for the table of subscriber records, and thus find record items of the subscriber. The process through which the current VLR address of the subscriber is searched for according to the called subscriber number is shown clearly in  
25 Fig.4. Fig.5 shows a preferred embodiment 3 in the present invention. Only the network in the home country is shown in Fig.5. The network comprises a plurality of sub-networks, each of which has a HLR; the RNM is connected with a plurality of HLRs and is shared by them. In this embodiment, besides above fundamental  
30 functions, RNM shall also deliver the following functions: first,

to distinguish different HLRs, RNM needs to store the mapping between subscribers and HLRs. Second, since the HLR directed to by the mobile phone numbers in the contracted roaming country is exclusive, in the route inquiry process, subscriber data may not be found in the HLR inquired by MSC; in this case, RNM shall, in accordance with the mapping between the subscriber and the HLR, inquire for routing information in the contracted HLR of the subscriber, and return the inquired HLR to MSC to instruct MSC to establish the call route. In this example, the numbers in the contracted roaming country can be shared among subscribers of different HLRs, to improve utilization rate of the roaming numbers in the contracted country.

Taking two roaming countries as an example, above embodiment is described; actually, roaming service in a plurality of roaming countries can be provided, and the number of roaming countries is only limited by the number of contracted countries by operators as well as storage capacity and processing capacity of HLRs. The method for localized roaming of mobile subscribers according to the present invention refers to that a subscriber (i.e., a mobile phone) in roaming state obtains a local number in the roaming region and initiates calls or answers calls using the number. Localized roaming service can reduce communication costs of mobile phone subscribers in roaming state greatly and meet roaming subscribers' communication demand well.

In the method according to the present invention, the operator that provides localized roaming service needs to obtain the numbers in certain roaming regions/networks for roaming service; these numbers are called contracted numbers, and the regions/networks that provide these numbers are called

contracted roaming regions/networks. For contracted numbers,  
their physical home region/network is the contracted roaming  
region/network; whereas their logical home region/network is  
the original home network where the localized roaming service  
5 is provided.

To implement localized roaming service, new functional  
entities - RNM is introduced in traditional cellular mobile  
communication networks. A RNM may manage mobile phone numbers  
in different regions/networks; whereas the mobile phone numbers  
10 in different regions/networks may be managed by different RNMs,  
i.e., a RNM can provide service for a plurality of HLRs, and  
a HLR can obtain service from different RNMs, depending on the  
subscriber's roaming region.

Taking roaming across countries as an example, the  
15 application environment of the present invention will be  
described, as shown in Fig.6. Fig.6 shows the connections between  
network structures and devices related with the present  
invention. There are 3 networks in the figure: a network in the  
subscriber's home country, a network in the contracted roaming  
20 country A and a network in the contracted roaming country B;  
wherein the cellular mobile network in the home country comprises  
two HLRs HLR(a) and HLR(b) and two RNMs RNM(a) and RNM(b) RNM(a)  
and RNM(b) manage local mobile phone numbers provided from the  
networks in contracted roaming country A and B, respectively.

25 It should be noted that the devices in the figure are not  
all devices of the network.

In Fig.6, BTS is a device that receives or transmits radio  
signals and serves for a certain region, and is connected to  
the subscribers in the region through radio connections; BTS

is connected to BSC, which manages radio resource and controls the operation of BTS; MSC is mainly used to control mobile call process; VLR is used to store the data of mobile phone subscribers who roam into its dominated region; Service GPRS Supporting Node  
5 SGSN controls establishment and release of packet service. HLR is used to store the subscribers' data including subscriber identification number, mobile phone numbers in the subscribers' home region, current default mobile phone numbers of the subscribers, types of contracted services, and current  
10 locations (addresses of VLRs), etc. RNM is used to manage mobile phone numbers obtained from the contracted roaming country, allocates temporary mobile phone numbers in the roaming regions to subscribers, and stores the mapping between subscribers and numbers, and releases the temporary numbers when subscribers  
15 leave contracted roaming countries. HLR, VLR, MSC and RNM cooperate with each other to manage mobile subscribers.

It is seen from Fig.6 that the structure of the cellular mobile communication network that implements localized roaming service is very flexible; there may be a plurality of RNMs and  
20 HLRs in the network; a RNM can provide service for a plurality of HLRs, a HLR can obtain service from different RNMs, depending on the subscriber's roaming region

Taking the Global System for Mobile Communications (GSM) as an example, the method for implementing localized roaming for  
25 subscribers in mobile communication system according to the present invention, referring to Fig.7, the method comprises:

Step 1: allocating independent PSTN/ISDN number and independent signaling point code, so that RNM can be addressed in the telephone signaling network;

30 Said step doesn't change the addressing for traditional

entities in the cellular mobile communication network;

Step 2: configuring appropriate data in the contracted roaming region/network and the home network, so that the subscriber location inquiry message taking the local number in the subscriber's roaming region/network as the destination address will be directed to RNM in the subscriber's home network;

For any call to a contracted number, inquiry for location of the called mobile phone subscriber in the RNM in the logical home region/network of the contracted number, taking the contracted number as the destination address, should be needed. A signaling path from the routing inquiry initiating device to the RNM is configured, and routing data at the network nodes in the signaling path is configured, so that the signaling message taking the contracted number as the destination address is routed correctly to RNM through the nodes in both the roaming region/network and the home network.

Usually, subscriber location inquiries are often initiated from a GMSC in the physical home cellular mobile communication network of the called number. If the caller is a subscriber in a PSTN, and the network capability is available, the inquiry may be initiated from any signaling point that supports Mobile Application Part (MAP), e.g., local exchanger, international tandem exchange center for outgoing calls, etc.

Step 3: establishing interfaces between RNM and relevant devices, including:

(1) Interface between RNM and MSC;

GMSC/SMS GMSC (Gateway Mobile Switching Center/Short Message Service Gateway Mobile Switching Center) inquires for routing information of the called subscriber in RNM, to accomplish call establishment and distribution of short

messages.

The interface employs MAP (Mobile Application Part), which corresponds to the signaling between GMSC and HLR.

(2) Interface between RNM and HLR;

5       This interface is used to exchange information between RNM and HLR, which includes location of the mobile phone, current number of the subscriber, and current subscriber location/routing information.

10       When the region/network where the mobile phone changes, HLR informs RNM of the location update of the subscriber's mobile phone; RNM determines whether to allocate a new number in the roaming region/network for the mobile phone and cancel the number that has been previously allocated in the roaming region/network according to the current location of the mobile phone.

15       When the mobile phone initiates a call with the subscriber's number in the roaming region, RNM receives a route inquiry, then accesses the HLR serving the subscriber corresponding to the number in the roaming region, and obtains the subscriber's routing information, and returns the routing information to the  
20       inquiring initiator;

The signaling employed by the interface is an extension to MAP (Mobile Application Part).

Above RNM addressing scheme has the following advantages:

25       First, it improves structural flexibility of cellular mobile communication network, i.e., a RNM can provide service for a plurality of HLRs, and a HLR can obtain service from different RNM's depending on the roaming region into which the subscriber is roaming, because subscribers, for which the localized roaming services are provided, may be distributed in different HLRs  
30       instead of converging in a HLR, in particular in the case of

a large-scale network. In addition, the mobile phone numbers in different roaming regions/networks may be managed by different RNMs;

Second, it ensures security of subscriber data in the home network: since the GMSC in the roaming region can't access the HLRs in the home region directly but has to access the HLRs through the RNM in the home region and can only obtain the data of a part of subscribers (subscribers who subscribe to localized roaming service), RNM can protect HLRs against unauthorized intrusion;

Third, the RNM is addressed through route inquiry according to the numbers in the roaming region; thus this method avoids addressing to different HLRs for numbers in different roaming regions and simplifies the modification of data configuration in the network. Since the subscribers in the network are distributed in different HLRs, if the contracted roaming phone numbers are allocated to the respective HLRs, the volume of signaling route configuration data described in step 2 will be increased drastically as signaling paths grow, especially when the signaling paths involve a plurality of signaling devices in the contracted roaming region/network and the home network, causing severe degradation of operability;

Forth, since some number in a roaming region is managed in a concentrated manner in RNM and shared by different subscribers in HLR, the utilization rate of the numbers is improved, the quantity of required numbers in the roaming region is decreased, and thus the interfaces between HLR and RNM are simplified. Since the subscribers in the network are distributed in different HLRs, if the contracted roaming numbers are allocated to the HLRs, the utilization rate of the numbers will be degraded, and more

contracted roaming phone numbers are required; or, though the method of sharing contracted roaming phone numbers among the HLRs may be used, that method will increase interfacing complexity, and the inquiry message may have to be transferred  
 5 between different HLRs and RNM.

Step 4: the subscriber utilizes the configuration of entities in the contracted roaming region/network and that in the home network to develop communication services in the roaming region/network; thus, localized roaming for the subscriber is  
 10 implemented, the details are as follows:

1. Subscriber location update process:

The embodiment of subscriber location update process is shown in Fig.8; wherein RNM (N) is the RNM corresponding to the current subscriber location/network; whereas RNM (0) is the RNM  
 15 corresponding to the old subscriber location/network (before location update). During the location update process, HLR informs the old VLR to delete the data of the subscriber; as a well-known flow, it is not shown in the Figure; the procedures include:

20 1) The VLR at which the subscriber is registered currently sends a location update request "Update Location" to the HLR in the subscriber's home region;

2) According to the current location of the subscriber, HLR informs RNM (N) of the subscriber location update via a "Location  
 25 Change" message, which shall carry at least the following messages:

Subscriber identifier: e.g., International Mobile Subscriber identifier (IMSI) and/or the subscriber's mobile phone number N in the home region;

30 current location of the subscriber: "current location";



old location of the subscriber: "old location";

3) When receiving the "Location Change" message, RNM (N) instructs the current default number of the subscriber to HLR via a "Number Activation" message, the parameter of which is number indicator N'. If RNM (N) has allocated a number to the subscriber (or the subscriber has a bound number in the roaming region/network), then N' is the number in the roaming region/network; if RNM (N) can't allocate a number in the roaming region/network to the subscriber, then N' indicates the HLR that the current default number of the subscriber is the number N in the home region (N' may not be N but a contracted special number, because RNM may be unable to obtain the subscriber's number in the home region); if the current location of the subscriber is in a roaming region/network different to the old roaming region/network and RNM has allocated a mobile phone number in the old roaming region/network for the subscriber, RNM will release that number (with the exception of number binding case);

4) HLR inserts subscriber data in VLR utilizing a "Insert subscriber data" message; wherein the subscriber's number is the current default number instructed by RNM (N);

5) The current VLR acknowledges insertion of subscriber data to the HLR in the home region utilizing a "Subscriber data insertion" message;

6) When receiving the acknowledgement for subscriber data insertion from VLR, HLR acknowledges the number allocation to RNM (N) utilizing a "Number activation ack" message; if RNM (N) doesn't receive the acknowledgement from HLR for a certain period, it will release the number that has been allocated;

7) If the phone number at the present location and the phone

number at the old location are managed by different RNMs, i.e., RNM (0) is different from RNM (N):

7.1) According to the old location, HLR informs RNM (0) utilizing a "Cancel Location" message to indicate the subscriber  
5 has left and requests to delete the subscriber data; the parameters of the message include: subscriber identifier and "Old Location";

7.2) RNM (0) returns a "Cancel Location ack" message to HLR to acknowledge deletion of data; the parameter of the message  
10 is the subscriber's identifier;

8) HLR returns an "Update location ack" message to VLR to confirm the location update process has been finished;

Both the message in step 2) and the message in step 7) carry the subscriber location information. This is necessary because  
15 a RNM may manage the numbers in a plurality of different roaming regions and thus it has to determine which number should be allocated/released according to the subscriber location.

The subscriber identifier described in above steps refers to a number that is used to distinguish the subscriber and  
20 identify subscriber identity, such as an IMSI or the subscriber's mobile phone number N in its home region.

Step 6) is carried out after step 5) is finished; thus, if session interruption between HLR and VLR leads to failure of subscriber data insertion, RNM can't receive acknowledgement  
25 of number allocation from HLR, it will release the allocated number, thus avoiding number occupation in case of abnormalities.

2. The signaling flow of calling the subscriber with the subscriber number N' in the roaming region/network (as shown  
30 in Fig.9):

1) When a call is initiated with the called subscriber's mobile phone number N' in the roaming region/network, a GMSC in the network (usually a GMSC in the roaming region/network) will initiate a route inquiry request to RNM;

5      2) When receiving the inquiry request, RNM finds the subscriber information according to the number in the roaming region, and send a "Send Routing Information" message with the subscriber identifier (IMSI or the number N in the home region) to inquire the route in the HLR in the home region;

10      3) HLR sends a "Provide Roaming Number" message to VLR to request to allocate a roaming number; the request contains the subscriber's IMSI;

4) VLR returns "Provide Roaming number ack" message to HLR to provide the allocated roaming number MSRN;

15      5) HLR returns a "Send Routing Information ack" message to RNM to provide the route inquiry result;

6) RNM forwards the "Send Routing Information ack" message to the GMSC to provide route inquiry acknowledgement, in order to instruct the route for GMSC with the roaming number obtained  
20 from HLR;

3. The signaling flow of sending short messages to the subscriber's number N' in the roaming region/network (as shown in Fig.10)

The process through which short messages are submitted to  
25 the short message service center is beyond the scope of the present invention. The Figure only illustrates the signaling flow of sending a short message from the short message service center to mobile phone. The short message service center SC and SMS GMSC in the Figure may be in any network, as long as the  
30 interface is compatible to the home network where the subscriber

is; the process through which SC issues a short message is as follows:

- 1) SC sends a short message to SMS GMSC, which initiates a route inquiry to RNM;
- 5      2) When receiving the inquiry request, RNM inquires the subscriber information according to the number in the roaming region, and sends a "Send Routing Information for SM" message with subscriber identifier (IMSI or the number N in the home region) to the HLR in the home region to inquire the route;
- 10     3) HLR sends a "Send Routing Information for SM ack" message to RNM to return the MSC number or SCSN number in the region where the subscriber stays;
- 4) RNM forwards the "Send Routing Information for SM ack" message to SMS GMSC as the acknowledgement for route inquiry,
- 15     to indicate the route for the short message according to the MSC number or SGSN number obtained from HLR;
- 5) SMS GMSC sends the short message.

The present invention doesn't require any change to traditional service features in the mobile communication  
20     networks; neither does it affect the traditional flows in the mobile communication networks. Taking the signaling flow of calling the subscriber with the number N in the home country H as an example, this advantage will be described, referring to Fig.11.

- 25     1) When a call is initiated with the called subscriber's mobile phone number N in the home region, a GMSC in the network (usually a GMSC in the home network) initiates a route inquiry request to HLR through a "Send Routing Information" message;
- 2) When receiving the inquiry request, HLR sends a "Provide  
30     Roaming number" message to the VLR in the region where the

subscriber is to request to allocate a roaming number;

3) VLR allocates a roaming number MSRN, and returns it to HLR through a "Provide Roaming number ack" message;

4) HLR sends a route inquiry acknowledgement to GMSC through  
5 a "Send Routing Information ACK" message, to instruct GMSC to establish calling route with the roaming number MSRN;

Above process is the same as the process through which a mobile subscriber in the traditional cellular mobile communication network is called; it will not be affected as more  
10 RNMs are added to the network.

Fig. 12 is the flow diagram of the second embodiment implemented with the method of the present invention. In this embodiment, taking subscriber roaming in a contracted roaming country and a non-contracted roaming country as an example, the  
15 present invention is further described. For convenience, it is supposed that only one RNM is used in the networks of each country.

As shown in Fig.12, with the method described in the present invention, the roaming service operator needs to obtain some  
20 local mobile phone numbers in other country for the international roaming service; these countries are called contracted roaming countries, the amount of the required phone numbers in a contracted roaming country depends on the number of subscribers roaming in that country; the more the roaming subscribers are,  
25 the more the numbers are required.

Please see Fig.2, which is the structural diagram of a cellular mobile phone network implemented with the method of the present invention. Fig. 2 illustrates the network devices related with the present invention and the connections among  
30 the devices. As shown in the Figure, for the same subscriber,

number N is used in the home country, a local mobile phone number N1 is used in the contracted roaming country A, and the number N in the home country is still used in the non-contracted roaming country B.

5       When the present invention is implemented in a network shown in Fig.2 according to Fig.12, the home country obtains the mobile phone numbers in the contracted roaming country first; when a mobile phone is roaming, in step A1, the mobile phone registers its location in the VLR in the roaming region through BTS, BSC  
10   and MSC because of change of mobile phone location; the VLR initiates a location update request to the HLR in the subscriber's home region. In step A2, HLR determines location change of the subscriber's mobile phone according to above request, i.e., if HLR detects the country has changed after  
15   location update of the mobile phone, it informs RNM the subscriber location update and requests to allocate a mobile phone number in the roaming country to the mobile phone. In step A3, the RNM in the home country determines whether the roaming country is a contracted roaming country; if the subscriber is  
20   in a contracted roaming country, in step A4, RNM allocates a number from the available numbers in the contracted roaming country and feeds it back to HLR, and stores the mapping between the subscriber and the number (a plurality of numbers may corresponds to the subscriber: the number in the home country,  
25   a temporary local number in the roaming region or bound numbers ); if the subscriber is not in a contracted roaming country, in step A5, NUM feeds the number in the home country back to HLR. The number fed back by RNM to HLR is called the current default number of the subscriber. In step A6, HLR takes the number fed  
30   back by the RNM in the home country as the current default number

of the subscriber and inserts it along with other data in the VLR in the region where the subscriber stays currently, deletes the subscriber's record in the old VLR, and updates mobile phone location information in the subscriber record; if the subscriber's current default number changes, HLR will inform the subscriber of the new current default number fed back from the RNM in the subscriber's home region. In Fig.2, when the subscriber roams from the home country to the contracted roaming country A, the RNM in the home country allocates a local mobile phone number N1 to the subscriber; the HLR in the home country inserts number N1 and other subscriber data in the VLR in country A where the subscriber stays currently, deletes the subscriber record in the VLR in the home country; when the subscriber roams into a non-contracted roaming country B, RNM instructs the subscriber's current default number is the number N in the home country; the HLR in the home country inserts the number N and other subscriber data (e.g., contracted data) into the VLR in country B where the subscriber stays currently.

On the basis of above steps, in step A7, when the subscriber receives an incoming call or initiates an outgoing call, the RNM will process the call. That is to say, if the mobile phone of the roaming subscriber is the caller, it uses the temporary roaming number allocated by RNM (i.e., the current default mobile phone number) to initiate the call; if it is the called, the caller may dial its local mobile phone number in the roaming country or its mobile phone number in the home country, and the MSC in the roaming country (if the caller dials the number in the roaming country) or the MSC in the home country (if the caller dials the number in the home country) inquires for the calling route in the HLR in the home country of the called subscriber;

the HLR in the home country inquires for the subscriber corresponding to the called number in the RNM in the home country (here the called number is a complete phone number comprising country code and local phone number) to find the corresponding subscriber record and obtain subscriber location information (i.e., the address of the VLR in the current roaming country), and thus obtains the route information through accessing the VLR in the roaming country, and then instructs the MSC in the roaming country to establish the call. In the RNM in home country, if any of the numbers maps to a subscriber, the mapping is unique; however, a subscriber may have been mapped to several numbers in different countries; no matter which number is dialed by the caller, a unique subscriber record can be found, and thus the subscriber location information is obtained. In Fig.2, when the subscriber roams into country A, the calling subscriber who calls the roaming subscriber may dial number N or N1.

In implementation of the embodiment shown in Fig.12, only when the country after subscriber location change changes, the action of allocating a mobile phone number in the roaming country will be triggered. As long as the subscriber stays in the country, above number will be used, until the subscriber leaves the country. After above phone number allocation process is finished, the network will inform the roaming subscriber of the temporary local number in the current roaming country by means of short message, voice or Unstructured Supplementary Service Data (USSD) or other ways, depending on the capability of the network and the operator's choice.

When the mobile phone subscriber leaves the contracted roaming country and enters into another country, the HLR in the home country will inform the RNM of the subscriber location



update, RNM will release the local mobile phone number occupied by the subscriber and break the mapping between the number and the subscriber. The time span from the number is allocated to the time it is released is called the life time of the number.

5 For example, as shown in Fig.2, when the roaming subscriber leaves country A, RNM will releases number N1.

In addition, in implementation of the embodiment shown in Fig.12, to avoid possible conflict between phone numbers during dynamic allocation, certain anti-conflict policies may be used  
10 to reuse released numbers. A simple but practicable policy is: the released number is locked temporarily within a certain time period, which is proportional to the life time of the number; after the time period, the number may be reallocated to a roaming subscriber.

15 If a mobile phone subscriber frequently travels between the home country and a contracted roaming country and requires to possess a number in the contracted roaming country, a number may be allocated to the subscriber from the available numbers in the contracted roaming country as a fixed number, which will  
20 not be allocated to any other roaming subscriber; even though the subscriber leaves the contracted roaming country, the mapping between the number and the subscriber is still maintained. Above operation is called number binding. When the subscriber roams into above contracted roaming country, the HLR in the home  
25 country is triggered by a location update request to request the RNM to allocate a local mobile phone number to the subscriber; RNM will return the bound number to HLR, so that the subscriber is enabled to use the bound number to process calls. When the subscriber doesn't need the bound number any more, the binding  
30 may be broken, and the number will be released and reused.

Certainly, usually a plurality of numbers in the contracted roaming countries may be bound to a subscriber.

When the caller dials a bound number of the called subscriber, the HLR in the home country determines the subscriber  
5 corresponding to that number through inquiring in the RNM, and inquires HLR to find the subscriber record, and obtain the subscriber location information (the address of VLR), to accomplish route inquiry. Therefore, if the called subscriber has bound numbers, the caller will have more choices: the called  
10 subscriber's number in the home country, bound numbers, or the number in the current contracted roaming country.

Taking two roaming countries as an example, the embodiment in Fig.12 is described; actually, localized roaming service can be provided in a plurality of roaming countries, and the number  
15 of roaming countries is only limited by the number of contracted countries contracted by operators as well as storage capacity of and processing ability of the RNMs.

It should be noted that the network and method for implementing localized roaming of mobile subscribers provided  
20 by the present invention are universal; for example, the present invention can be applied in domestic roaming regions as well as different cellular mobile communication systems including, but not limited to such systems as AMPS (Advanced Mobile Phone Service), GSM (Global System for Mobile Communications), D-AMPS  
25 (Digital-Advanced Mobile Phone Service), CDMA (Code Division Multiple Access), IMT-2000 (a generic term of third generation mobile communication systems defined by International Telecommunication Union). If the mobile terminals support diverse air interfaces (such as multi-mode terminals), the  
30 network and method can also be used to provide roaming service

among different systems.